Introduction

The effectiveness of a gaseous total flooding fire fighting system depends, in part, on retention of the air-extinguishant mixture within the protected enclosure for a period of time. Retention of the air-extinguishant mixture requires that the enclosure is well sealed to minimise leakage between the enclosure and the ambient environment.

Discharge of a gaseous fire fighting extinguishant into an enclosure will naturally result in a change of pressure in the enclosure. If the enclosure is sealed too tightly during the extinguishant discharge the pressure change could exceed the structural strength of one or more of its bounding surfaces – windows, doors, walls, ceiling. This can result in both failure of the enclosure and then failure of the gaseous flooding system to achieve suppression due to the air-extinguishant mixture leaking out through the structural failure.

In designing a gaseous total flooding system it is necessary to manage both the need for a well sealed enclosure, and the need to provide vent area to prevent over or under pressurisation of the enclosure and subsequent structural failure.

The fire protection industry has long known about discharge pressure dynamics for various types of fire extinguishing agents. Testing for Halon replacements in the early days of Halon replacement activities documented pressure relief requirements for Inert gas extinguishing systems for all manufacturers. What was not so clear was the requirements of Halocarbon agents - products like FM-200 and NOVEC 1230, which are the two most used Halocarbon agents used in New Zealand and Australia.

The discharge dynamics for Inerts versus Halocarbons are different and should be considered when designing any type of gaseous extinguishing system. The figures below show the different discharge pressure profiles associated with the different agent types.

Permissible Enclosure Pressures

In the early 1990s the NFPA2001 guidelines allowed the internal pressures differential for room structures to be 2500 Pascals for heavy weight construction, and 1200 Pascals for medium weight construction. These figures may have been suitable for the US but it was found that in many circumstances they were too high for UK and possibly Australian structures.

In 1993, following work carried out in conjunction with structural engineers, the figures that we use today were adopted - 500 Pascal’s for medium construction and 250 Pascal’s for light construction. These figures were then included in previous Australian Standards for gaseous extinguishing systems and have become industry-accepted conservative figures today. Though these figures give guidance to various construction types, enclosure strengths should be verified to ensure enclosure structural strengths are not exceeded.

Quantifying Vent Area

The issue of pressure relief venting was pushed forward in the 1990s with the push for Halon replacement technologies. Around this time the NFPA 2001 standard developed a testing procedure to quantify an enclosure’s natural leakage via the use of room pressurisation testing to predict the enclosure’s agent retention hold time. This was a positive step and became part of the industry’s overall assessment of agent retention and pressure relief.

The unfortunate part of quantifying an enclosure’s natural leakage was the potentially misguided belief that it could be used for all or part of the enclosure’s pressure relief venting. The problem with this approach to using the leakage area in place of dedicated pressure relief vents is that an enclosure’s natural leakage can change over the life cycle of the enclosure and suppression system, which creates a risk of over or under pressurisation should the enclosure become better sealed at any stage during its life cycle.
The LPC has guidelines that require a risk that is protected by Inert Gaseous Agents to be hermetically sealed to give the maximum hold time for the agent and the correct pressure vents fitted to prevent over or under pressurisation, and that no account is to be taken for the risks of natural leakage. This should be the case for all gaseous agents.

Thanks to the cooperative efforts of several fire protection equipment manufacturers and interested parties, experimental data has been obtained from testing a full range of agents (both inert and halocarbon) at the Fike facility in the US. This experimental data is the basis of the new “Fire Suppression Systems Association (FSSA) guide to Estimating Pressure Relief Vent Area’s”. The FSSA was the organisation that has collected and produced this guideline document for all agents.

What is new in the FSSA document is the quantification of negative and positive pressures for halocarbons during discharge. The fire industry now has something solid to ensure safe vent design and compliance.

The FSSA documentation clearly highlights the factors that influence maximum enclosure pressures, and discharge dynamic behaviour is clearer these days due to the FSSA testing.

The Fire Industry Association (UK) have also produced a document that explains more than just the quantification of formulas. It also guides the reader to other factors for consideration when reviewing or designing pressure relief venting, including guidance on cascade venting.

**Pressure Relief Vents Characteristics**

Different types of relief vents behave differently and this must be taken into account in the design of a pressure relief vent(s). Calculating the Free Vent Area (FVA) is only half of the overall design of a pressure relief venting system. The selected vent must actually deliver this FVA under discharge conditions.

The best performing vents are those that do not take much energy from the start of opening to fully open, and have blades that are designed to not introduce resistance to air flow. Balance bladed systems are one such vent type that is known to perform best under pressure relief conditions. Vents should also have a known FVA instead of an estimated FVA. When selecting the appropriate vent type the following design information is needed to ensure correct selection and design:

- Actual FVA of the vent taking into consideration the effectiveness of the vent blades efficiency at the predetermined maximum room pressure
• Pressure required to initiate opening of the vent/blades.
• Pressure required for the vent to open fully.
• What is the vent’s RTOP (Resistance to Opening Pressure) compared to an open hole.

Research has been undertaken by AFP Air Technologies UK that explores the impact of vent behaviour on pressure relief venting design. AFP undertook a series of tests using inert gases (as well as halocarbons) to establish the impact of standard vent types used in current gaseous suppression systems. The testing was conducted under the watchful eye of the British Research Establishment in the UK (BRE UK).

The testing established that each vent type and style had its own Dynamic Co-Efficient, which created marginally different enclosure pressures even when the suggested FVA provided by the vent manufacturer was stated to be the same for all vent types tested.

Dynamic Co-Efficient can be summed up as the force exerted on the vent blades when exposed to a very rapid increase in pressure or blast and the resistant back pressure produced. Unlike a co-efficient used for fire dampers, which is a fixed test with a damper open and a set air flow with a pressure drop measured and providing the results, with a dynamic co-efficient, that blast or rapid increase in pressure and resultant air flow, as well as the position of the vent blades, is measured over time. This will be measured in the space of one second. The only true way of achieving an understanding of a vent co-efficient is to carry out a live test, which must be based on a comparison with an open hole.

In the tests conducted by AFP Air Technologies the test enclosure was tested with gas discharge with an open hole area of 0.09m2. The resulting peak pressure recorded was 219 Pascals. Then three types of pressure relief vents were tested to compare peak pressures and establish each vent’s dynamic co-efficient or RTOP (Resistance to Open Pressure) co-efficient.

<table>
<thead>
<tr>
<th>Type of Vent</th>
<th>Dynamic Co-Efficient</th>
<th>Peak Pressure Recorded</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHX Vent (Balanced Bladed)</td>
<td>1.15</td>
<td>251 Pascals</td>
</tr>
<tr>
<td>HXD Vent</td>
<td>1.60</td>
<td>349 Pascals</td>
</tr>
<tr>
<td>Top Hinged, Bottom Weighted</td>
<td>3.61</td>
<td>790 Pascals</td>
</tr>
</tbody>
</table>

What is clearly shown with the different vent types tested is that all vents are not created equal. The comparison between a balanced blades SHX-style vent and a bottom-weighted, top-hinged vent created far different results for vents that were supposed to have an equivalent FVA. The testing conducted by AFP Air Technologies and the BRE UK clearly found that vent design plays an equally important role in pressure relief venting design, as does FVA formulae.

The tests conducted by AFP Air Technologies and BRE UK show that it is important that vent manufacturers conduct tests to establish the dynamic characteristics of the pressure relief vents to allow proper vent design and selection.

It has not been uncommon in the past for installers to use standard HVAC one-way flaps or louvers as pressure relief vents. These vents were not specifically designed for this service, and their suitability should be checked and confirmed by the system designer and manufacturer to ensure that the vents will be able to perform as required.

Conclusions & Recommendations

It is critical that specifiers and designers of gaseous fire suppression systems understand the discharge characteristics of the suppression agents being used and that the pressure relief vents installed are suitable for use with these agents (e.g. vents used with a halocarbon agent must allow venting in two directions).

The pressure relief vents used need to be correctly sized to give the required FVA under dynamic conditions at the pressures that will be present during gas discharge. The vents also need to be proven by testing to have suitable characteristics to ensure that they will safely prevent under or over pressurisation of the enclosure.

Failure to design or select appropriate pressure relief vents for gaseous fire suppression systems creates a risk that the structure of the protected enclosure will be damaged during a discharge. In addition, the gaseous suppression system may be rendered ineffective to leakage caused by the structural failure.

System designers and specifiers should be familiar with the latest guidance, including the Fire Industry Association (UK) guide, which can be downloaded from http://www.fia.uk.com/en/info/document_summary.cfm/docid/68A81813-ED03-4229-9F0DFDFA1D90CD9B.
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